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Original Article

Dietary patterns and sleep symptoms in Japanese workers: the Furukawa Nutrition and Health Study

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ABSTRACT

Objective: Experimental studies have shown that some nutrients are involved in initiating and maintaining sleep, but epidemiological evidence on overall dietary patterns and insomnia is scarce. We investigated the relationship between dietary patterns and sleep symptoms in a Japanese working population.
Methods: The participants were 2025 workers, aged 18–70 years, who participated in a health survey during a periodic checkup in 2012 and 2013. Dietary intake was assessed with a self-administered diet history questionnaire. Dietary patterns were extracted by principal component analysis on the basis of the energy-adjusted intake of 52 food and beverage items. Sleep duration, difficulty initiating and maintaining sleep, and poor quality of sleep were self-reported. Logistic regression was used to estimate the odds ratios of each sleep symptom according to quartile categories of each dietary pattern with adjustment for potential confounding variables.
Results: We identified three major dietary patterns. A healthy pattern, characterized by a high intake of vegetables, mushrooms, potatoes, seaweeds, soy products, and eggs, was associated with a decreased prevalence of difficulty initiating sleep once or more a week (P for trend = 0.03); the multivariate adjusted odds ratio in the highest quartile of this score compared with the lowest was 0.75 (95% CI: 0.57–0.99). This association persisted after the exclusion of individuals with severe depressive symptoms. However, there was no significant association with difficulty initiating sleep at least three times a week.
Conclusions: Our findings suggest that a healthy dietary pattern may be associated with difficulty initiating sleep at least once a week.

1. Introduction

Insomnia is a common clinical condition and is characterized by difficulty initiating or maintaining sleep [1]. In addition, short sleep duration (SSD) is a possible marker of the severity and chronicity of insomnia [2]. Insomnia symptoms were shown to have a prevalence of approximately 10% to 20%, depending on the definition used, among a Japanese population that was previously studied [3,4]. Old age, being female, depression, shiftwork, and low physical activity are all risk factors for insomnia symptoms [5–8]. Recently, increasing attention has been given to the role of diet as an etiologic factor of insomnia disorders [9–14].

Epidemiological studies have shown that subjects with SSD have higher intakes of energy-rich foods, which have higher percentages of energy from fat or refined carbohydrates, compared with subjects who sleep for long hours [11–13]. Among a Japanese population, a low intake of protein was associated with a high prevalence of difficulty initiating sleep (DIS) and poor quality of sleep (PQS), whereas a high-protein intake was associated with a high prevalence of difficulty maintaining sleep (DMS) [10]. Among Indian adults, insomniacs consumed a lower amount of protein, carbohydrate, thiamine, folate, vitamin B12 and iron, compared with normal sleepers [9]. In the 2007 to 2008 US National Health and Nutrition Examination Survey, higher carbohydrate intake was associated with decreased odds of DMS and higher calcium intake was associated with decreased prevalence of DIS and PQS [14].

Because foods are consumed in combination, the high correlation among the intake of individual foods and nutrients makes it difficult to separate the specific effects due to confounding and

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interaction [15]. To overcome these issues, the analysis of dietary patterns has gained much interest in nutritional epidemiology. Dietary patterns are the summary measures of several foods or food groups, and are expected to have a greater impact on disease risk than any single nutrient [16]. To date, studies on the association between dietary factors and insomnia symptoms have focused on nutrients [16]. Although limited evidence is available on the association between insomnia and special diets, including weight loss, low fat/low cholesterol, low salt/sodium and diabetic diets [13,17], evidence is lacking on the association with dietary patterns using dietary pattern analysis. Through a cross-sectional study, the association of dietary patterns in a Japanese working population, as defined by principal component analysis with insomnia symptoms (DIS and DMS), PQS and SSD was examined.

2. Materials and methods

2.1. Study procedure

As a part of the Japan Epidemiology Collaboration on the Occupational Health Study, the Furukawa Nutrition and Health Study, a nutritional epidemiological survey, was conducted at the time of a periodic health examination between April 2012 and May 2013 among workers of a manufacturing company and its affiliated companies in Chiba Prefecture and Kanagawa Prefecture, Japan. The primary objective of this study was to investigate the association between diet and physical and mental health. Prior to the health check-up, all of the workers ($n \approx 2800$) in these companies were invited to participate in the survey and asked to fill out two types of survey questionnaires (one specifically designed for diet and another for overall health-related lifestyle). Of these workers, 2162 agreed to participate, which was a response rate of approximately 77%. On the day of the health check-up, the research staff checked the questionnaires for completeness and, when necessary, clarified with the respondents. The participants were asked to donate 7 mL of venous blood for the study; additionally, health check-up data were obtained, including the results of anthropometric and biochemical measurements and information on history of disease. The study protocol was approved by the Ethics Committee of the National Center for Global Health and Medicine, Japan. Prior to the survey, written informed consent was obtained from all participants.

2.2. Participants

Of the 2162 workers who agreed to participate in the survey, 45, with a history of cardiovascular disease or cancer, and nine, with missing information on diet, were excluded, leaving 2108 workers (1883 men and 225 women) in the analysis of dietary patterns. A further three workers, with missing information on sleep symptoms, 42, with current medication for psychological diseases, and 38, with missing information on covariates, were excluded, leaving 2025 (1810 men and 215 women) available for the analysis of the association between dietary patterns and sleep symptoms. Workers with a history of cardiovascular disease or cancer, and with current medication for psychological disease, were also excluded because these conditions might affect both dietary habits and sleep symptoms.

2.3. Definition of outcome

Sleep symptoms were assessed based on three questions relating to sleep during the last month: (1) "how often have you had difficulties falling asleep in half an hour?" (DIS); (2) "how often have you woken up too early and not been able to get back to sleep?" (DMS); and (3) "how often do you feel a deep sleep at the time of awakening?" (restorative sleep with a feeling of satisfaction upon awakening). There were four response options: never or seldom, once or twice a week, three or four times a week, or five or more times a week. DIS and DMS were defined, according to a previous study, as present if a participant reported having each sleep problem once or more a week [3]; PQS was defined as present if a participant reported having restorative sleep with a feeling of satisfaction upon awakening less than once a week. Another cut-off value (at least three times a week) for the definition of DIS or DMS was used in accordance with the diagnostic and statistical manual of mental disorders (DSM-IV) [17]. The questions and response options about DIS and DMS were similar to those of the Japanese version of the Pittsburgh Sleep Quality Index [18,19], which is a reliable and valid measure for subjective sleep quality. Sleep duration was assessed using the following question: "how many hours of actual sleep do you get at night on weekdays?"; SSD was defined if a participant slept for less than 5 h/day, according to previous studies [20].

2.4. Dietary assessment

Dietary habits during the preceding month were assessed using a validated, brief, self-administered diet-history questionnaire (BDHQ) [21], which consisted of five sections: (1) the intake frequency of 46 foods and non-alcoholic beverages; (2) the daily intake frequency of rice and miso soup; (3) the frequency of drinking alcohol and the amount of consumption for five alcoholic beverages; (4) the usual cooking method; and (5) dietary behavior. An ad hoc computer algorithm for the BDHQ estimated dietary intakes for 58 food and beverage items, their contained energy and selected nutrients, with reference to the standard tables of food composition in Japan [22]. According to the validation study of the BDHQ, using 16-day semi-weighted dietary records as the gold standard, Spearman's correlation coefficients for 58 food and beverage items in 92 women, aged 31 years to 69 years, and 92 men, aged 32 years to 76 years, were 0.14 to 0.82 (median 0.44) and 0.22 to 0.83 (median 0.48), respectively [21].

2.5. Other variables

Other variables, including night and rotating shiftwork, job, marital status, smoking, alcohol consumption within 1 h of bedtime, leisure-time physical activity, depressive symptoms, a history of diabetes, and meal frequency (breakfast, lunch and dinner) were elicited in the survey questionnaire. Participants' smoking status (never, past or current smoker), as well as the duration of smoking in years and numbers of cigarettes smoked per day for past or current smokers, was asked. The frequency of consuming alcohol within 1 h of bedtime has not been covered in the previous section. (never, 0 < to <1 day/week, 1–2 days/week, 3–4 days/week, 5–6 days/week, or everyday) was asked. Leisure-time physical activity was expressed as the sum of the metabolic equivalent (MET) value multiplied by the duration of the activity. Depressive symptoms were assessed using a Japanese version of the Center for Epidemiologic Studies Depression (CES-D) scale [23]. Body height and body weight were measured. Body height was measured to the nearest 0.1 cm, with participants standing without shoes. Body weight was measured to the nearest 0.1 kg, with participants wearing light clothes. Body mass index (BMI) was calculated as weight in kg divided by height in m^2. Information on habitual snacking at night was obtained as part of the health check-up.

2.6. Statistical analysis

The principal component analysis on the basis of energy-adjusted intakes was performed by using a density method (amount

of food intake per 1000 kcal of energy) [24] of 52 food and beverage items, excluding six items (sugar added to coffee or black tea, three items usually added during cooking (salt, oil and sugar), table salt and salt-containing seasoning at the table, and soup consumed with noodles) to derive dietary patterns. The factors were rotated by orthogonal transformation (varimax rotation) to maintain uncorrelated factors and greater interpretability. The eigenvalues, the scree test, and the interpretability of the factors were considered in order to determine the number of factors (dietary patterns) to retain in the analysis. The dietary patterns were named according to the food items showing high loading (absolute value) on each factor. The factor scores for each dietary pattern and for each individual were calculated by summing the intakes of the food items weighted by their factor loadings. The factor scores were categorized into quartiles.

The participants were divided into quartiles, according to each dietary pattern score. The data were expressed as the means (SD) and percentages for continuous variables and categorical variables, respectively. Trend association was assessed by assigning ordinal numbers to each quartile of each dietary pattern score and was tested using a linear regression analysis or the Cochran–Armitage trend test, for continuous and categorical variables, respectively. A logistic regression analysis was performed to estimate the odds ratio and its 95% confidence interval (95% CI) for each insomnia symptom, PQS and SSD, according to the quartile of each dietary pattern score, and the lowest quartile was used as the reference category. In the multiple regression analysis, assigning the ordinal numbers 0–3 to the four categories of each dietary pattern score assessed trend association. Model 1 was adjusted for site, age (continuous, year) and gender. Model 2 was additionally adjusted for: night or rotating shiftwork (yes or no); job (white-collar or blue-collar worker); being married (yes or no); BMI (continuous, kg/m^2); smoking history (never smoked, smoked but quit, current smoker consuming <20 cigarettes/day, or current smoker consuming ≥20 cigarettes/day); alcohol consumption within 1 h of bedtime (never, 0< to 2 days/week, or ≥3 days/week); leisure-time physical activity (0 MET-h/week, 0< to <3 MET-h/week, 3 to <10 MET-h/week, or ≥10 MET-h/week); diabetic treatment (yes or no); energy intake (continuous in the log-scale, kcal per day); skipping one or more meals (yes or no); and habitual snacking at night (yes or no). In the sensitivity analyses, those who had severe depressive symptoms (CES-D scale ≥23) [25] ($n = 206$) were excluded because a severe depressive state might affect both dietary habits and sleep symptoms; shift-workers ($n = 409$) were also excluded because irregular working hours might lead to irregular sleeping habits and insomnia. In the analysis for the association between DIS and DMS three or more times a week, subjects with DIS or DMS once or twice a week were excluded. Two-sided p-values of less than 0.05 were considered to be statistically significant. All analyses were performed using Statistical Analysis System (SAS) software version 9.1 (SAS Institute, Cary, NC, USA).

Table 1
Factor loading matrix for major dietary patterns identified by principal component analysis ($n = 2108$).

Dietary patterns	Healthy	Westernized breakfast	Traditional Japanese
Carrots/pumpkin	0.72	0.09	0.03
Other root vegetables	0.69	0.06	0.00
Green leafy vegetables	0.69	0.10	0.04
Cabbage/Chinese cabbage	0.68	0.04	0.05
Mushrooms	0.64	0.09	0.09
Japanese radish/turnips	0.60	0.00	0.14
Lettuces/cabbage (raw)	0.59	0.07	−0.07
Seaweeds	0.50	0.01	0.20
Tomatoes	0.50	0.13	−0.09
Potatoes	0.46	0.06	0.00
Tofu/*atsuage* (deep-fried tofu)	0.42	−0.03	0.16
Mayonnaise/dressing	0.31	0.14	−0.22
Eggs	0.31	−0.06	−0.20
Pickled green leafy vegetables	0.29	−0.10	0.25
Black tea/oolong tea	0.18	0.08	−0.06
Green tea	0.17	0.09	0.10
Chinese noodles	−0.25	−0.05	−0.01
Other fruit	0.15	0.52	0.11
Persimmons/strawberries/kiwifruit	0.12	0.50	0.22
Western-type confectioneries	−0.04	0.47	−0.17
Bread	−0.04	0.45	−0.26
Citrus fruit	0.19	0.44	0.24
Japanese confectioneries	−0.02	0.42	0.14
Rice crackers/rice cakes/*okonomiyaki* (meat/fish and vegetable pancakes)	−0.06	0.38	0.14
Milk and yogurt	0.13	0.29	−0.09
Ice cream	−0.12	0.28	−0.11
100% fruit and vegetable juice	0.00	0.19	0.09
Low-fat milk and yogurt	0.11	0.16	0.02
Spaghetti and macaroni	−0.09	0.15	−0.07
Canned tuna	0.07	0.07	0.04
Whisky	−0.04	−0.15	0.02
Shochu	−0.14	−0.28	0.12
Miso soup	0.05	−0.32	0.13
Beer	−0.16	−0.35	0.03
Rice	−0.22	−0.49	−0.03
Dried fish/salted fish	0.17	0.00	0.52
Oily fish	0.18	0.04	0.50
Small fish with bones	0.18	0.03	0.46
Lean fish	0.26	0.05	0.46
Squid/octopus/shrimp/shellfish	0.14	0.11	0.35
Natto (fermented soybeans)	0.21	−0.09	0.28
Buckwheat noodles	−0.14	0.08	0.28
Japanese wheat noodles	−0.12	0.13	0.23
Sake	−0.07	−0.17	0.23
Pickled plums	0.19	−0.03	0.22
Liver	0.04	0.01	0.20
Wine	0.01	−0.06	0.08
Cola drinks/soft drinks	−0.17	0.10	−0.18
Coffee	0.08	0.03	−0.19
Ham/sausage/bacon	0.16	0.08	−0.23
Chicken	0.18	−0.02	−0.25
Pork/beef	0.12	0.04	−0.34
Variance explained (%)	10.3	4.5	4.0

3. Results

Three dietary patterns were identified (Table 1). The first pattern was characterized by: high intakes of vegetables, mushrooms, potatoes, seaweeds, soy products and eggs, and was named the healthy dietary pattern. The second dietary pattern was associated with: high intakes of fruits, bread, Western and Japanese type-confectionary and dairy products, and low intakes of rice, miso soup and alcohol drinks; this pattern was named the westernized breakfast pattern. The third pattern was characterized by: high intakes of fish and shellfish, *natto* (fermented soybeans), buckwheat noodles and pickled green leafy vegetables, and low intakes of red meat; this pattern was named the traditional Japanese dietary pattern. The first to third dietary patterns completely explained 18.8% of the variability.

The participants with higher scores of the healthy dietary and Westernized breakfast patterns were: older, more likely to be women, married, white-collar workers, and physically active during leisure time (healthy dietary pattern only); these participants were less likely to be smokers, shift workers, overweight (Westernized breakfast pattern only), less likely to drink alcohol within 1 h of bedtime, skip meals and snack at night (healthy dietary pattern only) than those with lower scores (Table 2). The participants with higher scores of the traditional Japanese pattern were: older, more likely to be men, drink alcohol within 1 h of bedtime, and skip one or more meal than those with a lower score. When considering dietary intake, with increasing scores of the healthy pattern and the traditional Japanese pattern carbohydrate intake was

Table 2
Characteristics of the study participants by quartile categories of each dietary pattern score in men and women ($n = 2025$).

Quartile categories of dietary pattern scores	Healthy dietary pattern			Westernized breakfast pattern			Traditional Japanese dietary pattern		
	Q1 (low)	Q4 (high)	Trend p[a]	Q1 (low)	Q4 (high)	Trend p[a]	Q1 (low)	Q4 (high)	Trend p[a]
Number of subjects	506	506		506	506		506	506	
Age (years)[b]	41.5 (10.0)	42.8 (10.4)	0.02	41.8 (10.7)	44.5 (10.0)	<0.0001	39.8 (9.0)	46.3(10.8)	<0.0001
Men (%)	93.5	83.2	<0.0001	97.8	78.5	<0.0001	86.4	91.5	0.006
Married (%)	57.5	67.0	<0.0001	61.9	69.2	0.01	65.6	67.6	0.25
Shiftwork (%)	31.0	10.9	<0.0001	27.6	14.2	<0.0001	18.6	17.4	0.36
White-collar worker (%)	48.6	71.7	<0.0001	51.2	68.4	<0.0001	60.9	60.1	0.85
Non-job PA (≥10 METS-h/week, %)	20.0	31.2	<0.0001	27.9	25.7	0.26	24.1	26.7	0.62
Body mass index (kg/m^2)[b]	23.1 (3.2)	23.1 (3.3)	0.31	23.6 (3.6)	23.0 (3.3)	0.003	23.0 (3.5)	23.4 (3.2)	0.09
Current smoker (%)	39.9	22.5	<0.0001	39.1	16.4	<0.0001	30.8	26.9	0.16
Alcohol drinker (≥23 g ethanol/day, %)	31.4	20.4	<0.0001	49.6	9.9	<0.0001	16.4	34.8	<0.0001
Alcohol consumed within 1 h of bedtime (≥3 days/week, %)	21.9	9.9	<0.0001	33.8	5.9	<0.0001	14.4	19.6	0.004
Skipping one or more meals (%)	33.4	16.6	<0.0001	27.5	13.8	<0.0001	26.5	16.0	<0.0001
Habitual snacking at night (%)	21.2	11.1	<0.0001	9.9	21.9	<0.0001	17.6	13.6	0.06
Sleep duration (≥7 h/day, %)	15.6	12.3	0.14	18.2	12.5	0.03	14.4	17.2	0.16
Diabetes (%)	1.8	2.4	0.66	2.4	3.0	0.42	2.2	4.4	0.02
Energy intake (kcal/day)[b]	1773 (542)	1769 (562)	0.95	1801 (490)	1794 (617)	0.90	1735 (479)	1894 (627)	<0.0001
Carbohydrate (% energy)[b]	57.5 (8.8)	52.1 (7.5)	<0.0001	53.4 (8.9)	55.0 (7.0)	0.004	54.5 (8.3)	53.4 (7.7)	0.003
Protein (% energy)[b]	11.9 (2.0)	15.6 (2.6)	<0.0001	12.8 (2.6)	14.5 (2.6)	<0.0001	13.4 (2.3)	15.1 (2.7)	<0.0001
Fat (% energy)[b]	20.8 (5.2)	26.8 (5.4)	<0.0001	20.3 (5.1)	27.0 (4.9)	<0.0001	26.7 (5.6)	22.8 (5.0)	<0.0001
n-3 fatty acids (% energy)[b]	0.95 (0.27)	1.37 (0.35)	<0.0001	1.08 (0.35)	1.22 (0.34)	<0.0001	1.09 (0.30)	1.37 (0.37)	<0.0001
Sodium (mg/1000 kcal)[b]	2190 (512)	2453 (466)	<0.0001	2246 (497)	2384 (503)	<0.0001	2139 (398)	2573 (503)	<0.0001
Potassium (mg/1000 kcal)[b]	899 (183)	1577 (327)	<0.0001	1098 (333)	1341 (371)	<0.0001	1178 (351)	1303 (362)	<0.0001
Calcium (mg/1000 kcal)[b]	176 (62)	305 (93)	<0.0001	197 (78)	279 (94)	<0.0001	219 (91)	267 (91)	<0.0001
Magnesium (mg/1000 kcal)[b]	104 (18)	151 (27)	<0.0001	123 (28)	132 (29)	<0.0001	117 (26)	140 (29)	<0.0001
Iron (mg/1000 kcal)[b]	2.9 (0.6)	4.8 (1.0)	<0.0001	3.6 (1.1)	4.1 (1.1)	<0.0001	3.6 (1.0)	4.3 (1.1)	<0.0001
Vitamin D (µg/1000 kcal)[b]	4.3 (2.7)	7.1 (4.0)	<0.0001	5.4 (3.4)	6.0 (3.5)	0.004	3.6 (1.9)	9.0 (4.1)	<0.0001
Vitamin B6 (mg/1000 kcal)[b]	0.5 (0.1)	0.8 (0.1)	<0.0001	0.6 (0.2)	0.6 (0.2)	0.008	0.6 (0.2)	0.7 (0.2)	<0.0001
Vitamin B12 (µg/1000 kcal)[b]	3.6 (1.8)	5.2 (2.5)	<0.0001	4.2 (2.1)	4.7 (2.5)	0.0004	3.1 (1.3)	6.4 (2.7)	<0.0001
Folate (µg/1000 kcal)[b]	114 (31)	225 (64)	<0.0001	156 (59)	180 (69)	<0.0001	155 (64)	182 (67)	<0.0001
Vitamin C (mg/1000 kcal)[b]	32 (16)	73 (26)	<0.0001	41 (21)	63 (29)	<0.0001	47 (24)	57 (27)	<0.0001
Niacin (mg/1000 kcal)[b]	7.8 (2.1)	10.4 (2.3)	<0.0001	9.0 (2.3)	9.1 (2.3)	0.63	8.8 (2.3)	9.8 (2.4)	<0.0001

Abbreviations: MET, metabolic equivalent; PA, physical activity; Q, quartile.
[a] Based on Cochran–Armitage trend test for categorical variables and linear regression analysis for continuous variables, assigning ordinal numbers 0 to 3 to quartile categories of each dietary pattern.
[b] Means (standard deviation).

decreased, but it was increased with an increasing score of the Westernized breakfast pattern. Protein and n-3 fatty acid intakes were increased with increasing scores of any pattern. Fat intake was increased with increasing scores of the healthy pattern and the Westernized breakfast pattern, but was decreased with increasing scores of the traditional Japanese pattern. Regarding energy-adjusted micronutrients, sodium, potassium, calcium, magnesium, iron, vitamin D, vitamin B6, vitamin B12, folate, and vitamin C were increased with increasing scores of all three patterns. Niacin was positively associated with the healthy pattern and the traditional Japanese pattern, but not with the Westernized breakfast pattern.

The prevalence of DIS (once or more a week), DMS (once or more a week), PQS and SSD was 34.9%, 41.5%, 24.5%, and 7.8%, respectively. Table 3 shows the odds ratio (OR) of sleep symptoms according to the quartile of each dietary pattern score. Multiple logistic regression showed that DIS decreased with an increasing score of the healthy dietary pattern; the multivariate-adjusted OR (95% CI) of DIS for the lowest through highest quartile were 1.00 (reference), 0.87 (0.67 to 1.14), 0.78 (0.60 to 1.03), and 0.75 (0.57 to 0.99) (p for trend = 0.03). The inverse association between DIS and the healthy pattern was also observed among subjects without severe depressive symptoms; the multivariate-adjusted OR (95% CI) of DIS for the lowest vs highest quartile were 0.71 (0.53 to 0.97) (p for trend = 0.04). A marginally significant inverse trend between DIS and the healthy pattern was observed among non-shift workers (p for trend = 0.050). As for the traditional Japanese dietary pattern, there were no significant associations with any sleep symptoms among all subjects. However, a marginally significant inverse trend between PQS and the traditional Japanese pattern was observed among non-shift workers; the multivariate-adjusted OR (95% CI) of PQS for the lowest vs highest quartile was 0.74 (0.52 to 1.04) (p for trend = 0.07). Additionally, none of the sleep symptoms were associated with the Westernized breakfast pattern. There were no significant associations of any dietary pattern with either DIS or DMS three or more times a week (data not shown).

4. Discussion

In this cross-sectional study of a Japanese working population, three major dietary patterns were identified: healthy, westernized breakfast, and traditional Japanese. Of these, the healthy pattern, which was characterized by high intakes of vegetables, mushrooms, potatoes, seaweeds, soy products and eggs, was associated with a decreased prevalence of DIS at least once a week. This association persisted after the exclusion of participants with severe depressive symptoms. Moreover, the traditional Japanese pattern, which was characterized by high intakes of fish, shellfish and *natto* and a low intake of red meat, was associated with a decreased prevalence, albeit statistically non-significant, of PQS among non-shift workers. However, there were no significant associations between any dietary patterns and DIS or DMS at least three times a week. It is believed that this is the first study to address the association between major dietary patterns and sleep symptoms.

In the present study, the healthy dietary pattern score was strongly correlated with a high intake of vegetables and was associated with a low prevalence of DIS (at least once a week). This association remained significant among those without a severe depressive state. Among male smokers aged 50 years to 69 years in the Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study, those with insomnia

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Table 3
Odds ratios and 95% confidence interval of sleep symptoms by quartile of dietary pattern score.

Multivariate-adjusted ORs (95% confidence interval)	Quartile categories of dietary pattern scores				
	Q1 (low)	Q2	Q3	Q4 (high)	Trend p[a]
Difficulty initiating sleep[b]					
Healthy dietary pattern					
Number of cases/participants	217/506	182/506	158/507	149/506	
Model 1 [c]	**1.00 (Ref)**	**0.76 (0.59–0.98)**	**0.62 (0.48–0.80)**	**0.58 (0.44–0.75)**	**<0.001**
Model 2 [d]	**1.00 (Ref)**	**0.87 (0.67–1.14)**	**0.78 (0.60–1.03)**	**0.75 (0.57–0.99)**	**0.03**
Westernized breakfast pattern					
Number of cases/participants	178/506	182/506	186/507	160/506	
Model 1 [c]	1.00 (Ref)	1.02 (0.79–1.33)	1.09 (0.84–1.41)	0.93 (0.71–1.22)	0.75
Model 2 [d]	1.00 (Ref)	1.16 (0.88–1.52)	1.32 (0.995–1.74)	1.20 (0.89–1.62)	0.15
Traditional Japanese pattern					
Number of cases/participants	180/506	180/506	176/507	170/506	
Model 1 [c]	1.00 (Ref)	1.01 (0.78–1.30)	1.02 (0.78–1.32)	1.05 (0.80–1.37)	0.74
Model 2 [d]	1.00 (Ref)	0.98 (0.75–1.28)	0.997 (0.76–1.31)	1.00 (0.76–1.33)	0.95
Difficulty maintaining sleep[b]					
Healthy dietary pattern					
Number of cases/participants	227/506	223/506	188/507	202/506	
Model 1 [c]	1.00 (Ref)	0.97 (0.75–1.24)	0.73 (0.57–0.95)	0.86 (0.67–1.11)	0.08
Model 2 [d]	1.00 (Ref)	1.06 (0.82–1.37)	0.87 (0.67–1.14)	1.08 (0.83–1.42)	0.91
Westernized breakfast pattern					
Number of cases/participants	218/506	218/506	207/507	197/506	
Model 1 [c]	1.00 (Ref)	1.05 (0.81–1.35)	0.98 (0.76–1.27)	0.93 (0.71–1.20)	0.49
Model 2 [d]	1.00 (Ref)	1.19 (0.92–1.55)	1.17 (0.89–1.53)	1.16 (0.87–1.54)	0.36
Traditional Japanese pattern					
Number of cases/participants	200/506	210/506	213/507	217/506	
Model 1 [c]	1.00 (Ref)	1.06 (0.82–1.37)	1.03 (0.80–1.33)	1.01 (0.78–1.32)	0.97
Model 2 [d]	1.00 (Ref)	1.02 (0.79–1.33)	0.97 (0.75–1.26)	0.95 (0.72–1.24)	0.62
Poor quality of sleep					
Healthy dietary pattern					
Number of cases/participants	143/506	130/506	109/507	115/506	
Model 1 [c]	1.00 (Ref)	0.87 (0.66–1.15)	0.69 (0.52–0.92)	0.74 (0.56–0.99)	0.01
Model 2 [d]	1.00 (Ref)	0.96 (0.72–1.28)	0.83 (0.61–1.12)	0.91 (0.67–1.24)	0.40
Westernized breakfast pattern					
Number of cases/participants	120/506	130/506	133/507	114/506	
Model 1 [c]	1.00 (Ref)	1.13 (0.85–1.50)	1.16 (0.87–1.54)	0.93 (0.69–1.26)	0.73
Model 2 [d]	1.00 (Ref)	1.22 (0.91–1.64)	1.25 (0.92–1.70)	1.03 (0.74–1.44)	0.81
Traditional Japanese pattern					
Number of cases/participants	132/506	124/506	120/507	120/506	
Model 1 [c]	1.00 (Ref)	0.90 (0.68–1.20)	0.84 (0.63–1.12)	0.81 (0.60–1.09)	0.13
Model 2 [d]	1.00 (Ref)	0.96 (0.72–1.28)	0.90 (0.67–1.21)	0.88 (0.65–1.19)	0.36
Short sleep duration					
Healthy dietary pattern					
Number of cases/participants	45/506	31/506	37/507	45/506	
Model 1 [c]	1.00 (Ref)	0.67 (0.41–1.07)	0.79 (0.50–1.24)	0.95 (0.61–1.47)	0.97
Model 2 [d]	1.00 (Ref)	0.70 (0.42–1.14)	0.90 (0.56–1.46)	1.06 (0.67–1.70)	0.58
Westernized breakfast pattern					
Number of cases/participants	32/506	36/506	43/507	47/506	
Model 1 [c]	1.00 (Ref)	1.11 (0.68–1.82)	1.31 (0.81–2.11)	1.41 (0.87–2.28)	0.13
Model 2 [d]	1.00 (Ref)	1.12 (0.67–1.86)	1.18 (0.71–1.96)	1.18 (0.70–2.00)	0.54
Traditional Japanese pattern					
Number of cases/participants	54/506	32/506	35/507	37/506	
Model 1 [c]	1.00 (Ref)	0.57 (0.36–0.90)	0.64 (0.41–0.99)	0.68 (0.43–1.07)	0.10
Model 2 [d]	1.00 (Ref)	0.58 (0.37–0.93)	0.72 (0.45–1.14)	0.75 (0.47–1.20)	0.29

Abbreviations: OR, odds ratio; Q, quartile; Ref, reference.
[a] Based on multiple regression analysis, with ordinal numbers 0 to 3 assigned to quartile categories of each dietary pattern.
[b] Difficulty initiating sleep and difficulty maintaining sleep were defined as being present if a participant reported having each sleep problem once or more a week.
[c] Adjusted for site, age (y), and gender.
[d] Adjusted for site, age (y), gender, BMI (kg/m^2), married (yes or no), shiftwork (yes or no), job (white-collar or blue-collar worker), leisure time physical activity (0, 0 < to <3, 3 to <10, ≥ 10 METS-h/week), smoking status (never and past, current and <20 cigarettes/day, or current and ≥20 cigarettes/day), alcohol consumption within 1 h of bedtime (never, 0 < to 2, ≥ 3 days/week), diabetes (yes or no), log transformed total energy intake (kcal/d), skipping one or more meals (yes or no), and habitual snacking at night (yes or no).

consumed less vegetables compared with those without insomnia [26]. The present results are in line with that study [26]. Moreover, in the present study, a greater difference was found between those in the lowest and the highest quartiles of the healthy pattern in the intake of some nutrients, including: protein, n-3 fatty acids, vitamin B6, niacin, magnesium, folate, vitamin C, calcium, iron and potassium, compared with those of other dietary patterns. Some of the above-mentioned nutrients (protein, n-3 fatty acids, vitamin B6, niacin and magnesium) have anti-insomniac effects [27]. A cross-sectional study among Japanese non-shift workers showed that a high-protein intake was associated with a decreased prevalence of DIS [10]; another study in India showed that insomniacs consumed less protein than normal sleepers [9]. Although evidence linking the intake of folate, iron, and calcium with insomnia symptoms is scarce, the study in India also showed that insomniacs had lower intakes of folate and iron compared with normal sleepers [9]. A cross-sectional study using US nationally representative data also showed that calcium intake was associated with decreased DIS [14]. Moreover, it has previously been

reported that higher serum folate concentrations are associated with a lower risk of depression [28], which frequently accompanies insomnia [29].

The mechanisms underlying the inverse association between DIS and the healthy pattern are unclear, but there are some possible explanations. Of the above-mentioned nutrients, protein includes tryptophan, which is a precursor to the neurotransmitter serotonin and the neurosecretory hormone melatonin. Serotonin controls brain functions, including the sleep cycle, either directly or indirectly [30]. Generally, serotonin promotes wakefulness but also regulates sleep through changes in the concentration of melatonin [27,30]. Melatonin exerts a hypnotic effect through thermoregulatory mechanisms by lowering the core body temperature, reducing arousal and increasing sleep-propensity [31]. Vitamin B6, pyridoxine, is required for the synthesis of serotonin from tryptophan [32]. The 5-Hydroxytryptophan is an intermediate in this process, and is converted to serotonin by a pyridoxal 5′-dependent enzyme [27,32]. Dietary niacin is involved in leaving more tryptophan to be used for the synthesis of serotonin [27,33]. In addition, folate is involved in the metabolism of monoamines like serotonin in the brain [33]. The N-3 fatty acids are required to convert serotonin to melatonin by the enzyme arylalkylamine-N-acetyltransferase [27]. Magnesium enhances the secretion of melatonin from the pineal gland by stimulating serotonin N-acetyltransferase activity, which is the key enzyme in melatonin synthesis [34]. In addition, given that oxidative stress can lead to insomnia [35], diets with a high score of the healthy dietary pattern, which is rich in antioxidant vitamins including vitamin C, may prevent the development of DIS through decreasing levels of oxidative stress. Therefore, the above-mentioned nutrients or their combination might have a beneficial role in initiating sleep.

In the present study, a suggestive inverse association between PQS and the traditional Japanese pattern score was observed among non-shift workers. The traditional Japanese pattern included a lot of fish and shellfish. Because these foods are rich in n-3 fatty acids, which are required in converting serotonin to melatonin [27], a diet rich in fish and shellfish could prevent insomnia. Fish and shellfish are also rich in glycine, which is an amino acid. An intervention study among Japanese volunteers aged 30 years to 57 years ($n = 11$) showed that glycine ingestion improved the satisfaction of sleep [36]. Vitamin B12, which contributes to the secretion of melatonin by enhancing melatonin receptors in the brain [37], is also abundant in fish and shellfish [22]. In the present study population, it was confirmed that there is a large difference in vitamin B12 intake between the lowest and the highest quartiles of the traditional Japanese pattern. These nutrients may jointly contribute to better sleep quality.

In the present study, the healthy dietary pattern was associated with a decreased prevalence of DIS at least once a week, but not DIS at least three times a week, which is used in DSM-IV as the clinical criteria [17]. This finding may suggest that diet influences only mild insomnia symptoms, but not clinically defined sleep disorders, which may be determined by factors other than diet. For instance, individuals with DIS at least three times a week had a much higher prevalence of severe depressive symptoms (CES-D ≥ 23: 35.8%), which is a strong risk factor for insomnia [7], than those with DIS once or twice a week (16.9%) in the present study.

Major strengths of the present study included: a high participation rate, the use of a validated dietary questionnaire, and adjustment for potentially important confounders. Limitations of the present study also warrant mention. First, an association derived from a cross-sectional study does not indicate causality. Second, the principal component analysis requires subjective decisions in determining the number of factors to retain, in choosing the method of rotation of initial factors, and in labeling the dietary patterns [16,38]. However, dietary patterns similar to the healthy dietary pattern [39–43], the westernized breakfast pattern [39,40,42–44], and the traditional Japanese pattern [39,41] in the present study have been observed in previous Japanese studies. Third, the three major dietary patterns accounted for 18.8% of the total variance of food intake in the present study. This figure, however, is average of previous Japanese studies (7.6% to 39.0%) [39–44]. The proportion of variance depends on the number of food items and the consolidation of food items into food groups, with total variance being higher in the analysis that used fewer numbers of food items or groups. Fourth, dietary intake was assessed only once and may not have represented long-term habitual intake that is relevant to insomnia symptoms. Thus, evidence could not be provided on the association of diet over a long period of time with insomnia symptoms. Fifth, the validity and reliability of the questionnaire items on sleep symptoms were not evaluated. Sixth, a possibility of residual confounding and unknown confounders cannot be excluded. Seventh, the response rate was approximately 77% and non-response bias is a concern. It was confirmed, however, that participants and non-participants were similar in terms of gender and age. Finally, because the study participants were workers of a company in Japan, the present findings might differ from the general population.

In conclusion, the healthy dietary pattern, which is characterized by high intakes of vegetables, mushrooms, potatoes, seaweeds, soy products and eggs, was associated with fewer DIS (at least once a week) in Japanese employees. The associations observed in this cross-sectional observational study need further confirmation in prospective studies.

Conflict of interest

The authors have declared that no competing interests exist. IK, TK, ME, HT, and RI are health professionals in the Furukawa Electric Corporation.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2014.09.017.

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